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REVIEWS

Meta-analysis: Multidisciplinary Fall Prevention Strategies in the Acute Care Inpatient Population

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BACKGROUND: Inpatient falls are common adverse events that lead to inpatient injury, increased length of stay, healthcare costs, litigation, and are a focus of patient safety and healthcare quality. Fall prevention methods are currently evolving to address the problem.

PURPOSE: To examine the available data evaluating multidisciplinary fall prevention strategies in the acute inpatient setting.

DATA SOURCES: A complete literature search of MEDLINE, CINAHL, EMBASE and the Cochrane Library through December 2011 was used. The bibliographies of all systematic reviews and meta-analyses were hand searched.

STUDY SELECTION: Only primary research studies relating to acute care inpatient hospital multidisciplinary fall prevention were included. Selected papers were assessed for quality by 2 authors using a 20-point scale previously used in the fall literature.

DATA EXTRACTION: Each selected study was carefully hand searched by 2 authors for the purposes of data extraction. Study results, in fall rate per 1000-patient days, and the characteristics of the interventions used were extracted for analysis.

DATA SYNTHESIS: Effect sizes (odds ratios) and 95% confidence intervals were derived for individual studies and then combined across research reports using a random-effects meta-analysis.

CONCLUSIONS: Fall prevention strategies have a significant but small effect on fall rates despite the use of complex, multidisciplinary interventions. Additional randomized trials are needed to examine the possible benefits of multidisciplinary fall prevention strategies in the acute inpatient setting. *Journal of Hospital Medicine* 2012;7:497–503. © 2012 Society of Hospital Medicine

Inpatient falls are the most common type of inpatient adverse event,[1] persist as a significant problem nationally, and result in patient injury, increased length of stay, healthcare costs, and litigation.[2–7] Inpatient falls remain a main focus of patient safety and a measure of quality in this era of healthcare reform and quality improvement.[8] Inpatient fall rates per 1000 patient-days range from 1.4 to 18.2.[4,9] The absolute percentage of inpatients that fall ranges from 1.3% to 7%.[4,5,9,10] Of inpatient falls, almost all data suggest that roughly one-third result in some type of injury while 3%-8% result in serious injury or death.[9,11–13]

Fall prevention interventions have largely been aimed at modifiable risk factors such as getting out of bed with bed alarms, toileting needs with bedside commodes, and reducing delirium through reorientation techniques. There have been several attempts at decreasing fall rates in hospitals surrounding a multidisciplinary, team-based approach. Two Cochrane reviews and 2 meta-analyses have partially examined this issue with mixed results.[14–17] However, none of these reviews focused on the acute care inpatient population. In fact, the majority of the data analyzed for inpatients was from rehabilitation wards and long-term care wards. Additionally, there exists almost no data examining fall prevention with single interventions in the acute inpatient population, likely due to the belief that falls are multifactorial in etiology and require more comprehensive interventions.

The aim of this article is to determine the impact of team-based, multidisciplinary quality improvement efforts to reduce inpatient falls in acute care inpatient hospitals and identify key features that determine their effectiveness.

METHODS

Data Sources and Searches

A search of MEDLINE, CINAHL, EMBASE, and the Cochrane Library was done using the medical subject heading (MeSH) terms "accidental falls," "accident prevention," "inpatients," and "prevention and control." Non-English language publications were included in the search. The search encompassed all published literature through December 1, 2011. In addition, reference lists of all systematic reviews and

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TABLE 1. Study Quality

Included Study	Clearly Defined Inclusion and Exclusion Criteria	Randomization	Comparable Treatment Groups at Entry	Identical Standard Program for Both Groups	"Fall Incident" Clearly Defined and Staff Trained in Definition	Blinded Treatment Providers	Blinded Outcome Assessors	Blinded Patients	Identical Appraisal of Outcomes*	Intention-to-Treat Analysis	Total Score (0-20)
Dykes et al[22]	2	2	2	2	2	0	0	0	2	2	14
Krauss et al[23]	2	0	2	2	2	0	0	0	2	2	12
Brandis[21]	1	0	1	2	2	0	0	0	2	2	10
Mitchell and Jones[25]	2	0	1	2	2	0	0	0	2	2	11
Schwendimann et al[9]	2	0	1	2	2	0	0	0	2	2	11
Williams et al[24]	2	0	1	2	2	0	0	0	2	2	11

* Defined as how study groups measured and reported patient falls.

meta-analyses were searched to identify all possible studies available.[14–16]

Study Selection

Only primary research studies relating to acute care inpatient hospital fall prevention were included. Data generated exclusively or partially from psychiatric wards, rehabilitation units, subacute facilities, and long-term facilities were excluded from the review.

Data Extraction and Quality Assessment

Each selected study was carefully hand searched by 2 authors for the purposes of data extraction. Data were collected for the following study characteristics and outcome measures: details of the fall prevention intervention used (allowing for all interventions used to be recorded in Table 3), markers of study quality, study period, study population, mean age of participants, sample size (in 1000 patient-days), and fall rates (in 1000 patient-days). In certain cases, sample size was converted to patient-days using reported data points of total number of patients and average length of stay.

Two authors with experience in fall literature discussed methodological quality and reached a consensus regarding scores using a 20-point scale previously described in fall literature for all studies included.[14,15] Ten individual criteria were scored on a 0-2 point scale. No points were awarded when the criteria were not met, not clearly mentioned, or not mentioned at all. One point was awarded when the criterion was partially met, and both points awarded when it was fully met.

Data Synthesis and Analysis

Fall rate per 1000-patient days was derived from reported data in both intervention and non-intervention groups within each study. Effect sizes (odds ratios [OR]) and 95% confidence intervals (CI) were derived for individual studies and then combined across research reports using an inverse weighted random-effects meta-analysis.[18] Random effects methodology was chosen to account for within-study and between-study variation. Statistical heterogeneity between trials was assessed using the Cochrane Q statistic and reported as I^2, which estimates the percentage of variability across studies that is not due to chance.[19] Due to the low number of included studies in our analysis, a formal statistical test on publication bias was not meaningful.[20] Statistical significance was defined as $P < 0.05$. Data analyses were done using Comprehensive Meta-Analysis, Version 2 (Biostat, Englewood, NJ).

RESULTS

Selected Studies

Electronic search produced 259 results on MEDLINE, 2 results from the Cochrane Library, 94 from CINAHL, and 4 from EMBASE. Each result was hand searched to exclude duplicates, and irrelevant studies. Once such data were excluded, the above inclusion and exclusion criteria identified 6 primary articles for review.[9,21–25] Additionally, a cluster randomized fall prevention trial in a mixed inpatient population was published by Cumming et al[26] in 2008. The study was excluded, as the participants were pooled between rehabilitation wards and acute inpatient wards, and only incomplete data were reported separately for the acute inpatient wards. We were unsuccessful at obtaining necessary data to analyze the acute inpatient wards.

Study Quality

The quality assessment results scores ranged from 11 to 14 out of a possible 20 (Table 1). None of the studies explicitly used an intention-to-treat statistical model, as the nature of inpatient care largely prevents drop-out or crossover, and all patients were included in individual study results.

Study Characteristics

The available data are skewed towards elderly patients being hospitalized in general medicine or geriatric units (Table 2). All but 1 study had a large sample size, with 1000-patient days ranging from 11.1 to 160.3.[9,21–24]

Components of the Intervention

Multidisciplinary interventions were complex, and formulated based on available evidence for individual

TABLE 2. Description of Studies Included in Systematic Review of Fall Prevention Strategies

Included Study	Study Design	Study Period	Study Wards	Mean Age	Sample Size With Intervention (1000 Patient-Days)	Sample Size in Control (1000 Patient-Days)	Fall Rate With Intervention (Falls per 1000 Patient-Days)	Fall Rate in Control (Falls per 1000 Patient-Days)
Dykes et al[22]	RCT	6 mo	2 Medical units	50% <65-17% 65-74 33% ≥75	24.1	24.1	4.18	4.64
Krauss et al[23]	Quasi-experimental	9 mo	General Medicine wards	65.5	11.2	11.39	5.09	6.85
Brandis[21]	Pre/post	12 mo	500-Bed acute care hospital	Not reported	160.3	155.2	1.61	1.74
Mitchell and Jones[25]	Pre/post	6 mo	Acute care hospital	76.23 (Pre) 72.1 (Post)	4.3	5	4.42	7.77
Schwendimann et al[9]	Pre/post	4 yr	Internal Med, Surgery, and Geriatrics	67.3	46.8	41.9	8.6	9.1
Williams et al[24]	Pre/post	6 mo	3 Medical wards and a Geriatrics ward	79	15.88	12.53	8	9.5

Abbreviations: RCT, randomized controlled trials.

TABLE 3. Components of the Multidisciplinary Fall Prevention Strategies

Included Study	Fall Risk Assessment Used	Mobility Assessment and Assistance if Necessary	Mobility Aid Provided if Necessary	Medication Modification	Education About Risk Factors	Fall Risk Sign/Warning in Chart	Bedside Interventions (eg, Bed Alarm, Rail Adjustment, Bed Location/Position, etc)	Toileting Schedule	Exercise Program	Other(s)
Dykes et al[22]*	+	+	+	+	+	+	+	+	−	Frequent bed checks, documented fall prevention plan
Krauss et al[23]	+	+	+	+	+	+	+	+	−	Use of bedside interventions was done based on discretion on a case-by-case basis
Brandis[21]	+	−	−	−	+	+	−	−	−	Ward modifications after OT assessment of patient rooms and bathrooms; hip protectors
Mitchell and Jones[25]	+	−	−	−	+	+	+	−	−	Introduced detailed system to track fall details; used other ''preventive actions'' not specified
Schwendimann et al[9]	+	+	+	+	+	+	+	+	+	Reassessment of patients who did fall; hip protectors
Williams et al[24]	+	+	+	−	−	+	−	+	+	Possible sitter

Abbreviations: OT, occupational therapy.
*

interventions and modifiable fall risk factors (Table 3). Each study reviewed included a fall risk assessment to risk-stratify participants and modulate intervention according to risk.[9,21–25]

Each study implemented fall prevention programs in a slightly different way. Krauss et al[23] used nurses to complete a Morse Fall Scale and subsequently implement several standard interventions based on risk. Staff was then authorized to employ bedside interventions as necessary without systematic data collection. Schwendimann et al[9] had nurses complete a simple fall risk assessment (based on history of falls, impaired mobility, and impaired cognition) that prompted the examination by a physician if risk was determined to be high. A subsequent team-based intervention was employed with nursing, physiotherapy, and the physician. Brandis[21] employed a team of nurses and the aid of the Director of Occupational Therapy to assess risk (using an undisclosed system) and carry out an intervention. Dykes et al[22] examined an electronic fall prevention tool kit (FPTK) using the electronic medical record (EMR). This intervention began with the Morse Fall Score, which triggered automatically ordered interventions that did not require personal oversight. In fact, the multidisciplinary interventions in the intervention group were also used in the control arm. The difference was the automatic nature in which the interventions were ordered in the interventions arm. Williams et al[24] used nurses and physiotherapists, who were specifically trained for the study, to carry out study interventions. The Mitchell and Jones[25] study focused on nursing care alone to carry out intervention and used a novel risk assessment tool.

Fall Rates

Dykes et al[22] and Williams et al[24] found a statistically significant reduction in fall rate with falls reduced by 1.16 per 1000-patient days and 1.5 per 1000-patient

Study Type	Study name	Statistics for each study				
		Odds ratio	Lower limit	Upper limit	Z-Value	p-Value
RCT	Dykes	0.900	0.688	1.179	-0.762	0.446
Quasi-experimental	Krauss	0.860	0.619	1.195	-0.896	0.370
Pre/Post	Brandis	0.925	0.780	1.097	-0.893	0.372
Pre/Post	Mitchell	0.567	0.327	0.983	-2.022	0.043
Pre/Post	Schwendimann	0.945	0.821	1.087	-0.795	0.427
Pre/Post	William	0.841	0.654	1.081	-1.353	0.176
Total		0.903	0.826	0.986	-2.262	0.024

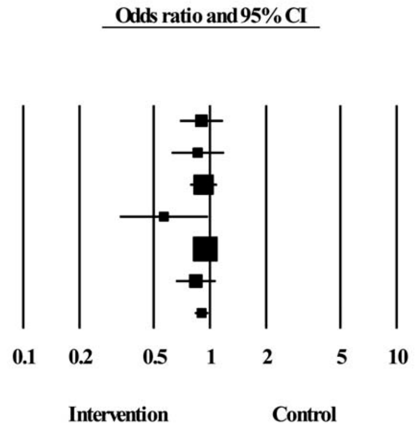

FIG. 1. Random-effects meta-analysis of the fall rate per 1000 patient-days in control groups compared to intervention groups. Odds ratios with 95% CI represent the 6 studies included in the meta-analysis. **Abbreviations: CI, confidence intervals; RCT, randomized controlled trial.**

days, respectively. Mitchell and Jones[25] demonstrated a large fall reduction but had an extremely small sample size. Brandis[21] found an extremely small reduction in fall rates and failed to report a *P*-value. Krauss et al[23] showed a trend towards reducing falls, and even showed a statistically significant reduction over the first 5 months of the study, but lost significance in the final 4 months. Similarly, Schwendimann et al[9] saw more impressive fall reductions in the first year of the study that dissipated in the final 3 years of data collection.

Results from the meta-analysis of the 6 studies comparing odds ratios are displayed quantitatively and as a forest plot in Figure 1. The figure shows results with 95% CI for each individual study and overall. There was no statistical evidence of heterogeneity between the studies or study designs. Although, due to the small number of studies included, there is poor power to detect true heterogeneity among studies. The magnitude of boxes shown is a relative sample size indicator. Using the random-effects model, the summary odds ratio is 0.90 (95% CI, 0.83 to 0.99) ($P = 0.02$) ($I^2 = 0\%$).[27]

DISCUSSION

The frequency and morbidity associated with inpatient falls is well established, based on reproduced epidemiologic data. Reducing these adverse events could reduce morbidity, mortality, and healthcare costs, and has become the focus of most hospitals quality and patient safety initiatives. The focus of this review was to examine multidisciplinary efforts to reduce falls in acute care inpatient hospitals. Despite the importance and scope of the problem, there is a paucity of research available on this topic, with a wide literature search yielding only 6 primary research studies.

Our major finding is that multidisciplinary fall prevention strategies have a statistically significant impact on fall rates with a combined OR of 0.90. While this review demonstrates a significant benefit to multidisciplinary fall prevention strategies in the acute inpatient population, the clinical impact of these efforts may be limited. Based on rates ranging from 1.7 to 9.5 falls per 1000-patient days, multidisciplinary interventions would reduce falls by 1 to 10 falls per 10,000-patient days using the combined OR calculated of 0.9. Using other available incidence data regarding inpatient falls,[4,9] a reasonable baseline frequency to consider would be 8 falls per 1000 patient-days. Assuming that prevalence, the number needed to treat (NNT) to prevent a single inpatient fall is 1250 patient days. Furthermore, based on available data, only approximately one-third of these falls result in injury and only a minor fraction of these results in serious injury.[9,11–13] The magnitude of this apparent benefit in the context of fall incidence rates raises some concerns about cost-effectiveness given the high staffing and systems needs that multidisciplinary prevention programs require. This also suggests that there are limitations when using inpatient falls as a measure of healthcare quality given the absence of high-quality evidence demonstrating a viable solution to the problem. At present, the Center for Medicare and Medicaid services limit reimbursement for fall-related injuries if they occur during an acute inpatient hospitalization.[28]

The complexity of the interventions used may help explain the limited impact. Krauss et al[23] examined compliance to their interventions and found less than ideal results. They found only 36.4% of intervention floor patients had maintained a toileting schedule compared to 24.6% on control floors. Additionally, a greater proportion of patients on control floors had a physical or occupational therapy consult, and only 1.8% more patients on intervention floors had walking aids provided. These were all strategies emphasized on the intervention floors. Similarly, Schwendimann et al[9] questioned their staff's adherence to protocol after fall prevention committee audits. This may help explain why a potential benefit lost statistical significance with time, based on a natural tendency towards more participation at the beginning of a new policy. Williams et al[24] reported only a 64% compliance rate with fall care plan forms and 77% rate of missing information on fall care plans. A multidisciplinary fall prevention study that did not meet inclusion criteria (based on study population) yielded strongly positive results for which the authors commented mostly on ''changing of the hospital culture'' surrounding fall prevention as a key to their success.[29] Adoptability of a multidisciplinary intervention will clearly impact adherence and the intervention's ultimate effectiveness.

Single intervention strategies, not analyzed in this review, are simpler to execute and adhere to. While these types of interventions may be superior, there is extremely limited data supporting or refuting patient fall benefits in the acute care inpatient population when using simple single interventions. However, some data generated partially on acute care geriatrics wards targeting patient education only showed benefit.[30]

Dykes et al[22] was able to improve compliance rates by removing steps in the process of executing interventions with the FPTK built into the EMR. Importantly, the FPTK was compared against very similar fall prevention strategies, the difference being that patients randomized to the FPTK arm had the assessment and interventions automatically prompted on admission in the EMR. Adherence was measured through Morse Fall Scale completion rates (81% in control units versus 94% in intervention units).[22] In many ways, the utility of this study was displaying a fall risk reduction by simply enhancing compliance using health information technology with automated alerts. Additionally, both arms of the study reported low fall rates compared to previously reported data, and there may have been larger benefit seen if the FPTK was compared against no fall prevention strategy. This diminishing of effect size may have been present in all studies reviewed, as usual hospital care commonly includes basic patient safety measures.

Another potential problem with the multidisciplinary fall prevention programs included in the meta-analysis is the inability to target interventions. Each study employed a fall risk score in an attempt to focus resources on a select group of high-risk patients. This method is problematic given that countless risk factors for inpatient falls have been identified in the literature. Factors that have been described range from clinical characteristics to laboratory tests.[31] The most consistently reproducible patient-related risks are altered mental status (including cognitive impairment and depression), altered mobility (particularly lower limb weakness), a history of falls, and toileting needs.[13,32–36] Less consistency is seen with other traditional risk factors such as age, sedating medication, and length of stay.[5,13,32,36–38] Attempting to risk-stratify patients using simple and accurate assessment tools developed from these risk factors has proven to be very difficult. Many tools have been developed based on identified risk factors, but perform very poorly when trying to identify patients who will fall with reasonable specificity and positive predictive value.[34,39–44] In fact, it has been demonstrated that using a nurse's judgment, a physician's opinion based on a patient's likelihood to wander or a simple 2-question tool have all performed better than sophisticated risk calculators.[33,45,46] Therefore, it is possible that interventions could benefit from including all patients, with de-emphasis on unproven risk stratification tools.

In contrast to our findings, a modest risk reduction has been demonstrated in several primary articles and meta-analyses in the subacute, rehabilitation, and long-term care populations.[15,16,47–50] Additionally, a recent study has described a 63.9% risk reduction in a population that included medical, surgical, psychiatric, and rehabilitation wards.[29] One important difference between these settings and the acute inpatient populations may be the amount of time and energy that can be dedicated to fall prevention and overall care planning. Another likely factor is the added challenge of preventing falls in patients with more active medical illnesses. In the acute care setting, a patient's chief complaint may not be completely addressed at the time of first mobilization and ambulation. This may be most relevant in patients who are admitted with syncope, seizure, vertigo, and dehydration.

Our study has several limitations; most notably, the available evidence is limited in quality and quantity. Furthermore, omission of unpublished data may also lead to effect bias, though this would likely be in the direction of ineffective interventions supporting a conclusion that multidisciplinary efforts have had only a small impact on fall rates. Ideally, future studies can limit confounding variables through randomization. However, it is difficult to adequately blind when studying a multidisciplinary fall intervention that depends on patient and provider participation. As a result, none of the papers reviewed met criteria for high quality. However, almost all available data examined in this review came from large sample sizes in which thoughtful interventions were used. Since an inpatient fall will not affect the majority of patients, it was crucial for these studies to recruit a large sample size to have adequate power to detect a difference in fall rates. However, each study used risk assessment tools, which are poor indicators of who will and will not fall in the hospital.[34,39,42] This may suggest a need for improved risk assessment tools, or be further evidence to include all patients in fall prevention regardless of risk. Quantitative synthesis of multidisciplinary fall interventions has the added limitation of comparing complex, multifaceted treatments that are not perfectly uniform. It is our opinion that interventions are semi-standardized using the grouping methods employed in Table 3.

Preventing inpatient falls remains a difficult issue to address while convincing data is lacking. Based on current evidence, multidisciplinary fall prevention efforts on acutely ill inpatients show a possible small benefit and should be explored from a cost-effectiveness standpoint to ensure they garner appropriate investment. Many resources are required to run such teams including nursing staff, equipment, physical and occupational therapy staff, pharmacists, and specialized staff training. We are unaware of any such cost-effectiveness data available. Effective interventions may be those that maximize compliance through health information technology, maintain staff dedication, increase staff availability, improve risk assessment, or include all patients regardless of calculated fall risk, and take the patient's chief complaint into account in the fall prevention strategy. Where resources are limited, it appears most reasonable to focus on major risk factors for inpatient falls that have independently been shown to be detrimental to outcomes, such as delirium.[51] Additionally, using inpatient fall rates as a hospital quality measure may be premature, given the lack of proven efforts to lower fall rates. Multidisciplinary fall prevention efforts on acutely ill inpatients should be further studied using high-quality, randomized trials. It remains to be seen whether these large programs are cost-effective, or on balance clinically effective.

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